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विद्युत रासायनिक विश्लेषक की कार्यकारिता अभिव्यक्ति

भाग 1 सामान्य

Indian Standard

EXPRESSION OF PERFORMANCE OF ELECTROCHEMICAL ANALYZERS

PART 1 GENERAL

UDC 621·35·035 : 541·13·08

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 5

Electronic Measuring Equipment Sectional Committee, LTD 21

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Electronic Measuring Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

The object of this standard is to specify the terminology and definitions related to the functional performance of electrochemical analyzers used for the continuous determination of certain aspects of aqueous solutions and requirements for statements by manufacturers. It is also intended to cover the tests necessary in order to determine the functional performance and such tests.

This standard is in accordance with the general principles given in IS 9176 : 1979 'Method for specifying the functional performance of the electronic measuring equipment'. Standard ranges of analogue d.c. current and pneumatic signals used in process control systems are covered in IS 7722 : 1975 'Analogue pneumentic signals for process control systems' and IS 7728 : 1984 'Analogue document signals for process control systems (*first revision*)'. Requirements for documentation to be supplied with instruments are covered in IS 6756 : 1972 'Technical documentation to be supplied with electronic measuring equipment'.

While preparing this standard (Part 1), assistance has been derived from IEC Pub 746 (Part 1) : 1982 'Expression of performance of electrochemical analyzers : Part 1 General', issued by the International Electrotechnical Commission (IEC).

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it should be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

EXPRESSION OF PERFORMANCE OF ELECTROCHEMICAL ANALYZERS

PART 1 GENERAL

1 SCOPE

1.1 This standard (Part 1) is applicable to electrochemical analyzers used for the determination of certain properties of (generally aqueous) solutions such as *p*H value, electrical conductivity, dissolved oxygen content, the concentration of specified ions and redox potential.

1.2 It includes the terminology, definitions, requirements for statements by manufacturers and tests that are common to all electrochemical analyzers. Other standards in this series describe those aspects that are specific to certain types, for example, IS 13673 (Part 2) : 1992 'Expression of performance of electrochemical analyzers : Part 2 *p*H value'.

1.3 It is applicable to analyzers specified for installation in any location and to such analyzers having either flow-through or immersible type sensors.

1.4 It is applicable to the complete analyzer when supplied by one manufacturer as an integral unit comprised of all mechanical, electrical and electronic portions. It also applies to sensor units alone and electronic units alone when supplied separately or by different manufacturers.

For the purpose of this standard, any regulator for mains-supplied power or any non-mains power supply, provided with the analyzer or specified by the manufacturer, is considered part of the analyzer whether it is integral or housed separately.

1.5 It does not apply to accessories such as recorders, analogue-to-digital converters or data acquisition systems, used in conjunction with the analyzers except that when two or more such analyzers are combined and sold as a sub-system and a single electronic unit is supplied to provide continuous measurement of several properties, that readout unit is considered to be part of the analyzer. Similarly, e.m.f.-to-current or e.m.f.-to-pressure converters that are an integral part of the analyzer are included.

1.6 Safety requirements are covered in IS 9858 : 1981 'Safety requirements for electronic measuring apparatus'.

2 REFERENCES

2.1 The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 DEFINITIONS

The definitions contained in IS 9176 : 1979 and the following apply for the purposes of this standard.

3.1 Electrochemical Analyzer

An analytical instrument that consists of an electrochemical sensor unit and an appropriate electronic measuring equipment (hereinafter referred to as "sensor unit" and electronic unit respectively).

3.2 Sensor Unit

A transducer consisting of one or more components from which is derived an electrical output related to that property of the sample which is to be measured. Examples of electrochemical sensor units are: *p*H, ion-sensitive and redox potentiometric cells, dissolved oxygen sensor units, conductance cells.

3.3 Simulator

A device which provides well-defined electrical properties of the device being replaced, and which has errors that are negligible in comparison with the errors to be determined.

3.4 Calibration Solution

An aqueous solution of known value of the property being measured, used for periodic calibration and for various performance tests.

NOTE — For the purposes of this standard, the values of these solutions represent the conventionally true values (*see* **3.9.2.1**) against which the indicated values are compared. The values of the calibration solutions should be traceable to reference material according to international or national standards, or agreed upon by the manufacturer and the user, and the uncertainty of the conventionally true values shall be stated.

3.5 Test Solution

A solution of approximately known value of the property being measured, which is stable in value over an extended period of time.

3.6 Performance Characteristic

One of the quantities assigned to an apparatus in order to define by values, tolerances, ranges, etc, the performance of the apparatus.

3.7 Influence Quantity

Any quantity, generally external to an apparatus, which may affect the performance of the apparatus.

3.8 Values Related to Quantities

3.8.1 *Rated Value*

The value (or one of the values) of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the apparatus.

3.8.2 *Rated Range*

The range of the quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the apparatus.

3.8.3 *Effective Range*

That part of the rated range where measurements can be made or quantities be supplied within the stated limits of performance.

3.8.4 *Span*

The algebraic difference between the upper and lower values of the rated range.

3.9 Terms Selected to the Specification of Performance

3.9.1 *Performance*

The degree to which the intended functions of the equipment are accomplished.

3.9.2 *Error*

3.9.2.1 *Absolute error*

The error, expressed algebraically in the unit of the measured quantity. For measuring apparatus, the error is the indicated value of the measured quantity minus its true value.

NOTES

1 The true value of a quantity is the value that would be measured by a measuring process free from error.

2 In practice, since this true value cannot be determined by measurement, a conventionally true value, approaching the true value as closely as necessary (having regard to the error to be determined), is used in place of the true value. This value may be traced to reference material according to international or national standards or agreed upon by the manufacturer and the user. In both cases, the uncertainty of the conventionally true value shall be stated.

3.9.2.2 *Relative error*

The ratio of the absolute error to a stated value.

3.9.2.3 *Percentage error*

The relative error, expressed as a percentage, such as percent of span, percent of the indicated or pre-set value or of the rated value.

3.9.2.4 *Fiducial value*

A value to which reference is made in order to specify the percentage error, such as scan or another clearly stated value.

3.9.3 *Linearity Error*

The maximum deviation between actual analyzer readings and the readings predicted by a linear function of the measured quantity which includes the indicated values at the upper and lower limits of the effective range.

3.9.4 *Intrinsic Error*

The error determined under reference conditions.

3.9.5 *Operating Error*

The error determined under rated operating conditions.

3.9.6 *Influence Error*

The error determined when one influence quantity assumes any value within its rated range of use, all others being at reference conditions.

3.9.7 *Interference Error*

The error caused by interfering substances being present in the sample.

3.9.8 *Limits of Error*

The maximum values of error assigned by the manufacturer to a measured quantity of an apparatus operating under specified conditions.

3.9.9 *Repeatability*

The spread of the results of successive measurements at short intervals of time of identical test material, carried out by the same method, with the same measuring instruments, by the same observer, in the same laboratory, in unchanged environmental conditions.

NOTE—A time interval equal to about ten times the 90% response time of the analyzer may be considered a short interval.

3.9.10 *Stability*

The spread of the results of successive measurements at much longer time intervals than for repeatability (**3.9.9**) on identical test material, carried out by the same method, with the same measuring instruments, by the same observer, in the same laboratory, in unchanged enviromental conditions, without any adjustments by external means.

3.9.11 *Operating Period*

The maximum time interval within which the limits of operating error are not exceeded, without adjustment by external means.

3.9.12 *Output Fluctuation*

The peak-to-peak deviations of the output with constant input and constant influence quantities.

3.9.13 *Minimum Detectable Change*

The change in value of the property to be measured equivalent to twice the output fluctuation.

3.9.14 *Delay Time* (T_{10})

The time interval from the instant a step change occurs in the value of the property to be measured to the instant when the change in the indicated value passes (and remains beyond) 10 percent of its steady-state amplitude difference.

3.9.15 *Rise (Fall) Time* (T_r, T_f)

The time interval within which the indicated value passes from 10 percent to (and remains beyond) 90 percent of its steady-state amplitude difference after a step change occurs in the value of the property to be measured.

3.9.16 *90 Percent Time* (T_{90})

The time interval from the instant a step change occurs in the value of the property to be measured to the instant when the change in the indicated value passes (and remains beyond) 90 percent of its steady-state amplitude difference, that is, $T_{90} = T_{10} + T_r$ (*or* T_f)

The relation between T_{10}, T_r (T_f) and T_{90} is given in Fig. 1.

3.9.17 *Warm-up Time*

The time interval after switching on the power, under reference conditions, necessary for a unit or analyzer

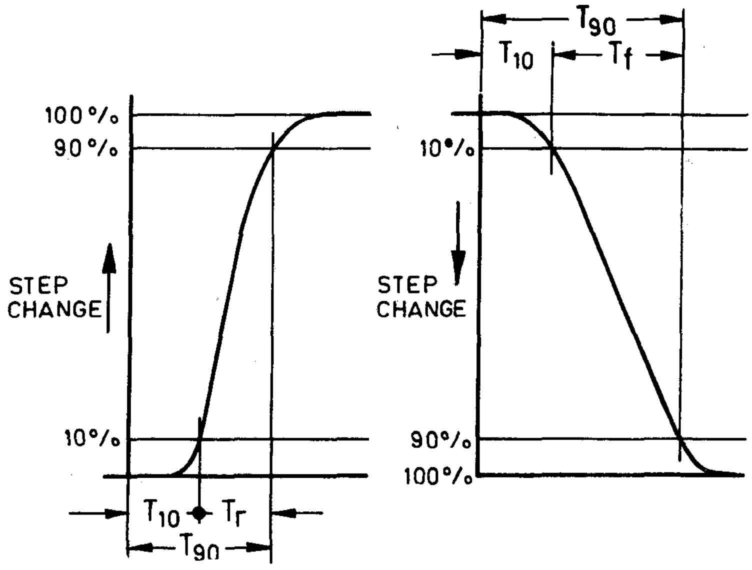

FIG. 1 RELATION BETWEEN T_{10}, T_r (T_f) AND T_{90}

to comply with specific limits of error.

3.10 Terms Related to Conditions of Operating, Transport and Storage

3.10.1 *Reference Conditions*

A set of values with tolerances, or of restricted ranges of influence quantities specified for making comparison and calibration tests.

3.10.2 *Rated Range of Use*

The range of values for an influence quantity within which the requirements concerning operating error are satisfied.

3.10.3 *Rated Operating Conditions*

The whole of the effective ranges for performance characteristics, and rated ranges of use for influence quantities, within which the performance of the apparatus is specified.

3.10.4 *Limit Conditions of Operation*

The whole of the ranges of values for influence quantities and performance characteristics (beyond the rated ranges of use and effective ranges respectively) within which the apparatus can function without resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions (*see* **4.2.2**).

3.10.5 *Conditions of Storage and Transport*

All the conditions of temperature, humidity, air pressure, vibration, shock, etc, within which the apparatus may be stored or transported in an inoperative condition, within resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions.

4 PROCEDURE FOR STATEMENT

4.1 Manufacturers delivering complete analyzers, or sensor units or electronic units, shall provide statements on the following.

4.1.1 The rated values for the performance characteristics are listed in **4.3**. The rated values for these performance characteristics shall not be outside their effective ranges.

4.1.2 The limits of error are listed in **4.4**.

4.1.3 The performance characteristics are listed in **4.5**.

4.1.4 The reference values of ranges, the rated ranges of use and the limit ranges of operation, storage and transport, for all influence quantities shall be stated and shall be selected from only one of the usage Groups I, II or III in **5**. Any exceptions to the values given there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

NOTE — The analyzers or electronic units may correspond to one group of rated ranges of use for environmental conditions and to another group of mains supply conditions but this should be clearly stated by the manufacturer.

4.1.5 *Materials of Construction in Contact with Sample*

4.2 Statements shall be made on rated operating conditions and limit conditions of operation in such a way that the following requirements are met, unless otherwise specified.

4.2.1 The apparatus, while functioning, shall show no damage or degradation of performance when any number of performance characteristics and/or influence quantities assume any value within the limit conditions of operation during a specified time, or, if no time is specified, for an unlimited time.

4.2.2 The apparatus shall show no permanent damage or degradation of performance when being inoperative, it has been subjected to conditions where any number of influence quantities assume any value within their storage or transport conditions during a specified time, or, if no time is specified, for an unlimited time.

NOTE— Absence of degradation of performance means that, after re-establishing reference conditions or rated operating conditions, the apparatus again satisfies the requirements concerning its performance.

4.3 Performance Characteristics Requiring Statements of Rated Values

i) Minimum and maximum rated values for the property to be measured (range or ranges).

ii) Minimum and maximum rated values for output signals corresponding to the rated values as given in **4.3**(i).

These signals shall be stated in units of voltage, current or pressure. If stated in units of voltage, the minimum allowable load, in ohms, shall also be stated. If stated in units of current, the maximum allowable load, in ohms, shall also be stated.

For the analyzer or electronic unit, all multiple outputs shall be stated additionally. If a capacitive or inductive load will influence the output signal, this shall be specified.

If the analyzer output signal is electrical current, *see* IS 7728 : 1989. If it is pneumatic, *see* IS 7722 : 1975.

iii) Rated ranges of use for sample conditions at the analyzer inlet for an on-line analyzer, or at the sensor unit for an immersible sensor type analyzer, including flow rate (if appropriate), pressure and temperature, also the rated maximum rate of change for sample temperature.

4.4 Error Limits to be Stated for Each Specified Range

i) *Operating Error*

NOTE— For the purposes of this standard, the stated operating error of the sensor unit or analyzer does not include effects of interference errors or effects of variation in sample temperature or pressure. These are stated separately and shall be considered as additional to the operating error as stated by the manufacturer.

ii) *Intrinsic Error* (which applies under reference conditions) may be stated in addition for comparison and calibration purposes.

iii) *Linearity Error for Electronic Unit or Analyzer*

NOTE — Deviation from linearity is strictly considered as an error only if a linear output is claimed.

iv) *Interference Errors* where known, shall be stated in terms of the equivalent level of the property to be measured. The specifications of interfering components, their concentration levels and test methods shall be made by agreement between the manufacturer and the user except where other publications in this series state specific requirements.

v) *Repeatability*

This value is to be stated on the basis that no adjustments shall be made by external means during the test.

vi) *Stability*

This value is to be stated on the basis that no adjustments shall be made by external means during the stated time intervals. The warm-up time is always excluded from the time interval. The time interval shall be chosen from the list in **6.7.4**.

4.5 Other Performance Characteristics

Although no statements of error limits are required for the performance characteristics listed below, the manufacturer shall state their values or ranges for each specified operating range :

a) Output fluctuation for electronic unit or analyzer

b) Minimum detectable change for electronic unit or analyzer

c) Delay time (T_{10})

d) Rise (fall) times (T_r T_f)

e) 90% time (T_{90})

f) Warm-up time for electronic unit or analyzer

g) Operating period for sensor unit or analyzer

h) For sensor unit or analyzer, the quantitative effect on indicated value of the property to be measured produced by variation of the sample temperature

j) For sensor unit and analyzer, the quantitative effect on indicated value of the property to be measured produced by variation in the sample pressure

k) For sensor unit and analyzer, the quantitative effect on indicated value of the property to be measured produced by any other sample conditions (for example flow rate)

4.6 For analyzer, the manufacturer shall state if the sensor unit of the analyzer can be replaced only by an exact equivalent of the original or also by any sensor unit having the same characteristics. In the latter case, he shall give the necessary specifications of the sensor unit.

5 RECOMMENDED STANDARD VALUES AND RANGES OF INFLUENCE QUANTITIES AFFECTING THE PERFORMANCE OF THE ELECTRONIC UNIT

The rated ranges of use of the influence quantities below have been divided into the following three usage groups:

I : For indoor use under conditions which are normally found in the laboratories and factories and where apparatus will be handled carefully.

II : For use in environments having protection from full extremes of environment and under conditions of handling between those of Groups I and III.

III : For outdoor use and in areas where the apparatus may be subjected to rough handling.

NOTE — These influence quantities generally affect the electronic units directly and apply specifically to them. The sensor units, being immersed in the sample are affected primarily by the sample conditions and these influence quantities do not relate to them. In the case of *in situ* analyzers, where both sensor units and electronic units are immersed in the sample, the sample conditions, rather than these influence quantities, relate to the electronic unit also. The effects of the external environment on the sensor unit may need to be stated separately.

5.1 Climatic Conditions

5.1.1 *Ambient Temperature*

- Reference value : 20°C, 23°C, 25°C, 25°C or 27°C
- Tolerance on reference value : ± 2°C
- Rated ranges of use : I : + 5°C to + 40°C;
  - II : –10°C to + 55°C; and
  - III : –25°C to +70°C.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.
- Limit range for storage and transport : – 40°C to +70°C.

5.1.2 *Relative Humidity of the Air*

Because extreme values of both temperature and humidity are not likely to occur simultaneously, the manufacturer may specify the time limit over which these may be applied and shall specify the limitations of the combination, if any, for continuous operation.

- Reference range at 20°C, 23°C, 25°C or 27°C : 45 percent to 75 percent.
- Rated ranges of use : I : 20 percent to 80 percent excluding condensation;
  - II : 10 percent to 90 percent including condensation; and
  - III : 5 percent to 95 percent including condensation.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.1.3 *Barometric Pressure*

- Reference value : Existing local barometric pressure
- Range of reference value : "70 to 80 kpa"
- Rated ranges of use : I and II :
  - ± 5 percent of any mean local barometric pressure between 70.0 kPa and 106.0 kPa.
  - III : To be stated by the manufacturer.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.1.4 *Heating Effect Due to Solar Radiation*

- Reference value : No direct irradiation
- Rated ranges of use: I and II :
  - No direct irradiation;
  - III : The combined effect of solar radiation plus the ambient temperature should never cause the surface temperature to exceed that which is obtained at an ambient temperature of 70°C alone.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.1.5 *Velocity of the Ambient Air*

- Reference range : 0 m/s to 0.2 m/s
- Rated range of use : I and II :
  - 0 m/s to 0.5 m/s, and
  - III : 0 m/s to 5 m/s.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by manufacturer.

5.1.6 *Sand and Dust Contents of the Air*

- Reference value : No measurable contents.
- Rated ranges of use: I and II :
  - Negligible contents (that is, will have negligible effect on the analyzer);
  - III : To be stated by the manufacturer.
- Limit range of operation : Equal to the rated range of use unless otherwise stated by manufacturer.

- Limit range for storage and transport : To be stated by manufacturer.

5.1.7 *Salt Contents of the Air*

- Reference value : No measurable contents.
- Rated ranges of use: I and II : Negligible contents.
  III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer
- Limit range for storage and transport : To be stated by the manufacturer.

5.1.8 *Contaminating Gas or Vapour Contents of the Air*

- Reference value : No measurable contents.
- Rated ranges of use: I to III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer.
- Limit range of storage and transport : To be stated by the manufacturer.

5.1.9 *Liquid Water Contents of the Air*

- Reference value : No measurable contents
- Rated ranges of use: I : Negligible contents;
  II : Drip water; and
  III : Splash water.
- Limit range of operation : To be stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.2 Mechanical Conditions

5.2.1 *Operating Position*

- Reference value : Position as stated by the manufacturer.
- Tolerance on reference : ± 1°
- Rated ranges of use: I and II : Reference position ± 30 percent; and
  III : Reference position ± 90 percent.
- Limit range of operation : To be stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

NOTE– These rated ranges of use should be understood only for the electronic units without orientation-sensitive indicators. For electronic units with built-in orientation-sensitive indicators the manufacturer should make suitable statements.

5.2.2 *Ventilation*

- Reference value : Ventilation not obstructed.
- Rated ranges of use: I to III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer.

5.2.3 *Vibration*

- Reference value : No measurable value.
- Rated ranges of use: I : Negligible value; and
  II and III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.2.4 *Mechanical Shock*

- Reference value : No measurable value
- Rated ranges of use : I to III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.2.5 *Sound Pressure*

- Reference value : No measurable value.
- Rated ranges of use : I to III : To be stated by the manufacturer.
- Limit range for storage and transport : To be stated by the manufacturer.

5.3 Radiation

- Reference value : To be stated by the manufacturer.
- Rated ranges of use : I to III : To be stated by the manufacturer.
- Limit range of operation : To be stated by the manufacturer.

5.4 Mains Supply Conditions

5.4.1 *Mains Supply Voltage (Considering a Distorted Waveform)*

		D. C. and *A.C.* (r.m.s.)	*A.C* (peak)
– Reference value :		←—Rated value—→	
– Tolerance on reference value :		± 1%	± 2%
– Rated ranges of use :	I	± 10%	± 12%
	II	– 12% to +10%	– 17% to +15%
	III	To be stated by the manufacturer	

5.4.2 *Mains Supply Frequency*

- Reference value : Rated frequency
- Tolerance on reference value : ± 1 percent
- Rated ranges of use: I and II : ± 5 percent III : ± 10 percent (Unless otherwise stated by the manufacturer).
- Limit range of operation : To be stated by the manufacturer.

5.4.3 *Distortion of a.c. Mains Supply*

The distortion is determined by a factor β in such a way that the waveform is inside an envelope formed by:

$\gamma_1 = (1 + \beta)$ A sin wt

$\gamma_2 + (1 - \beta)$ A sin wt

- Reference value : $\beta = 0$. (sine wave)
- Tolerance on reference value : $\beta = 0.05$
- Rated ranges of use: I : $\beta = 0.05$; and II and III : $\beta = 0.10$.
- Limit range of operation : To be stated by the manufacturer.

The values are valid when the analyzer is connected to the supply mains.

NOTES

1 The above formulae may be applied over the half cycle or a full cycle depending on whether the zero crossings are equally spaced or not.

2 If the ac peak voltage exceeds the values stated in **5.4.1**, the mains supply under consideration cannot be used.

6 VERIFICATION OF VALUES

6.1 Compliance tests shall be performed with the apparatus ready for use (including accessories) after warm-up time and after performing adjustments according to the manufacturer's instructions.

In the case of special applications where these tests are not appropriate, additional test procedures may be agreed upon between the manufacturer and the user.

6.1.1 In general, measurements for verification shall be carried out with instruments which do not appreciably (or only calculably) affect the value to be measured. In principle, the errors in measurements made with these instruments should be negligible in comparison with the errors to be determined. (*See also* **6.2**).

6.1.2 When the error of the test instrument is not negligible, the following rule should apply:

> If an apparatus is claimed to have a limit error of ± *e* percent for given performance characteristics and the manufacturer used for its checking an instrument resulting in an error of ± *n* percent, the error being checked shall remain between the limits ± (*e* – *n*) percent.
>
> Likewise, if a customer checks the same apparatus using another instrument resulting in an error of measurement of ± *m* percent, he is not entitled to reject the apparatus if its apparent error exceeds the limits ± *e* percent but remains between the limits ± (*e* + *m*) percent.

6.1.3 Unless otherwise specified, the influence quantities shall be at reference conditions during the tests concerned and during the tests the apparatus shall be supplied with its rated voltage and frequency. (*See also* **6.6**).

6.1.4 The sensor unit shall be in optimal conditions as specified by the manufacturer and due consideration shall be given to the flow conditions around the sensor.

6.1.5 Adequate agitation of all test solutions shall be provided, if required.

6.2 Test equipment shall include all of the necessary test solutions. (*See* **3.4** and **3.5**).

6.2.1 Test equipment shall also include appropriate simulators for testing electronic units in those cases where such units are supplied separately from sensor units and for sensor units in such cases where they are supplied separately from electronic units. In these cases, **6.1.1** and **6.1.2** apply to the simulators. Specifications for appropriate simulators may vary from one type analyzer to another. Therefore, such specifications are covered in the parts of Indian Standards dealing with specific analyzers.

6.3 During tests, adjustments by external means may be repeated at the intervals prescribed by the manufacturer or at any suitably interval, if such adjustment does not interfere with the error to be checked.

Adjustments shall also be performed when error values have expressly been quoted to be valid only after such adjustment. Measurements shall then be made immediately after such adjustmen so that any drift will not influence them.

6.4 When measuring the intrinsic error of a performance characteristic, the combination of values and/or ranges of influence quantities shall remain within the reference conditions which include relevant tolerances on reference values.

6.5 When measuring the operating error of a performance characteristic, the combination of values and/or ranges of influence quantities may vary up to the limits of the rated operating conditions.

6.6 When measuring the influence error of a performance characteristic due to an influence quantity, all other quantities shall remain within reference conditions. The relevant influence quantity may assume any value within its rated range of use.

6.7 Test Procedures for Electronic Units

Procedures for sensor units alone and for complete analyzers are described in the subsequent parts of Indian Standards for specific analyzers since they vary for different types. These tests are repeated for each rated input range. The errors may be expressed as absolute errors, relative errors or percentage errors, but the one selected shall be identified. Where one of the modes of expression is specified, it shall be used.

6.7.1 *Operating Error*

Using an appropriate simulator, a signal representing the approximately mid-scale value of the rated input range is applied to the electronic unit. With all influence quantities at their reference values, the output reading of the unit is recorded, in terms of the units of the proprty to be measured.

In turn, the ambient temperature, the relative humidity, the power supply voltage and the power supply frequency are shifted to the limits of their rated operating conditions and the output readings are recorded for each condition.

The maximum deviation in recorded values shall be within the stated operating error.

NOTE – When temperature or humidity is shifted, sufficient time should be allowed to observe the maximum effect.

6.7.2 *Linearity Error*

At least five approximatey uniformly distributed signals, with two of them representing very nearly the limits of the rated input range of the electronic unit, are applied from a simulator and the readings are recorded. A straight line drawn between the indicated values at the upper and lower limits of the effective range.

The maximum deviation between the recorded values and this straight line is the linearity error. It is expressed in terms of the units of the property to be measured.

NOTE — This test should be combined with the repeatability test. The uncertainty limits due to repeatability should be taken into account.

6.7.3 *Repeatability*

Using an appropriate simulator, signals representing approximately the minimum and the maximum rated input values are applied to the electronic unit and the indicated values are recorded.

These steps are repeated N times (where $N \geq 6$) and the standard deviation is calculated for all N values recorded (for each input value).

The mean standard deviation is calculated and reported.

6.7.4 *Stability*

Using an appropriate simulator, signals representing approximately the minimum and the maximum rated input values are applied to the electronic unit and the indicated values are recorded.

These steps are repeated after the specified time interval and the differences for both sets of readings are reported.

The time interval for which the stability limits are stated should be chosen appropriately for the specific application from the following values:

15 min
1 h
3 h
7 h
24 h
7 days
30 days
3 months
6 months
1 year

6.7.5 *Output Fluctuation*

Using an appropriate simulator, a signal representing the approximately mid-scale value of the rated input range is applied to the electronic unit for a period of 5 min and the maximum peak-to-peak value of the random, or regular, deviation from the mean output is determined.

The test is repeated three times and the average of the readings is reported in terms of percentage of the span.

NOTES

1 For the purpose of this standard, spikes caused by the influence of external electromagnetic fields or by supply mains spikes are considered as due to changes in influence quantities and are, therefore ignored in the determination of output fluctuation.

2 In the case of the electronic unit or analyzer having variable time constants in the output circuit, the output fluctuation shall be stated for the same time constant as used for the statement of delay time rise time, fall time and 90% time.

6.7.6 *Delay Time (T_{10}), Rise (Fall) Time (T_r, T_f) and 90 Percent Time (T_{90})*

Using an appropriate simulator, signals representing the minimum and maximum rated input values are applied successively to the electronic unit and left until a constant reading is obtained on the recorder chart.

The values for delay time (T_{10}) for both increasing and decreasing step changes, rise time (T_r), fall time (T_f) and 90 percent time (T_{90}) for both increasing and decreasing step changes are determined through knowledge of the chart speed. The larger of the two delay times, the larger of rise or fall time and the larger of the two 90 percent times are reported. (*See* Fig.1).

6.7.7 *Warm-up Time*

The electronic unit is switched off and all of its components are allowed to cool to the reference temperature. The unit is switched on and, using an appropriate simulator, a signal representing between 75 percent and 95 percent of the span is applied to the electronic unit, and the reading is recorded. Recording is continued until the deviation in reading over a 15 min period is not greater than the sum of the stated repeatability and stability. Warm-up time is determined as the interval from the time the electronic unit is switched on until the beginning of this 15 min period.

NOTE – This test does not include the warm-up time for an automatic temperature compensating circuit if its sensor would be located with the electromechanical sensor unit.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
6756 : 1972	Technical documentation to be supplied with electronic measuring equipment
9176 : 1979	Method for specifying the functional performance of the electronic measuring equipment
7722 : 1975	Analogue pneumatic signals for process control systems
9858 : 1981	Safety requirements for electronic measuring apparatus
7728 : 1984	Analogue document signals for process control systems (*first revision*)
13673 (Part 2) : 1993	Expression of performance of electrochemical analyzers: Part 2 *p*H Value

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